Nuclear MythBusters Notes

Presentation Objective – communicate facts so that people can make informed decisions about what to believe

Slide 2 – Apologies to Bill Murray and Dan Aykroyd

4 myths promoted by people who oppose nuclear energy

- dirty bombs
- suitcase nukes
- nuclear fuel reprocessing results in nuclear weapon proliferation
- nuclear plants can explode like nuclear bombs

Slide 4 – fictional dirty bomb

- dirty bombs back in news – Russian officials accused Ukrainian government of planning to use dirty bombs in armed conflict that began February 2022
- portrayed as lethal nuclear weapons
- truth is dirty bomb far less scary than media and their so-called “experts” make it sound

Slide 5 – the dirty bomb

- not weapon of mass destruction
- primary purpose is “area denial" and terror weapon
- produces terror in public because of radiophobia
- useful as terror weapon because radiation protection agencies promote radiophobia by using LNT dose-response model and ignoring biological adaptive protection
  - small radiation doses stimulate body’s adaptive protection mechanisms resulting in enhanced repair of cellular damage
- psychological damage from detonation of dirty bomb likely be far-reaching
- even Centers for Disease Control & Prevention guidance on radiological dispersion devices acknowledges main danger comes from explosion, not radiation
- potential for any radiation-induced health risk can be avoided by immediately leaving area of dirty bomb detonation
- potentially significant radiation exposures result only from inhalation of radioactive material; external exposures inconsequential
- relatively long-term exposure to ionizing radiation necessary to produce detrimental health effects

Slide 6 – dirty bomb material

- radioactive material routinely used at hospitals, research facilities, and industrial and construction sites regulated in U.S. by NRC and some state governments

- missing or stolen licensed material must be reported to licensing authorities
- most licensed materials not suitable for causing significant radiation exposures when dispersed by explosion

Slide 7 – dirty bomb material (cont.)

- bomb must be easily transportable
- radioactive material must be reduced to powder form to be scattered across target zone, but not too fine to be widely scattered by strong winds

Slide 11 – fictional suitcase nuke

- suitcase nuke myth propagated by those who know better, but want to convince unknowing public that suitcase-sized nuclear devices secretly deployed in U.S. by terrorists

Slide 12 – portable nuclear weapons

- lightest nuclear device tested by U.S. weighed about 100 pounds with maximum yield of 190 tons of TNT equivalent

Slide 14 – suitcase nuke (cont.)

- images on web showing gun-type weapon mounted in suitcase don’t accurately reflect how big device would be to function as nuclear weapon
- implosion-type weapon requires large quantity of explosives to sufficiently compress fissile material into supercritical mass
- bringing suitcase-sized nuclear device into kiloton yield range requires very efficient utilization of fissile material, adding significant complexity and weight to such device

Slide 15 – gun-type assembly device

- graphic of uranium atom bomb (Little Boy) dropped on Hiroshima, Japan on August 6, 1945
- gun barrel of gun-type nuclear weapon too long to fit into suitcase

Slide 16 – implosion-type device

- graphic of plutonium atom bomb (Fat Man) dropped on Nagasaki, Japan on August 9, 1945
- quantity of high explosives required for implosion-type nuclear weapon too bulky to fit into suitcase

Slide 17 – suitcase nuke (cont.)

- idea that terrorists could create nuclear device of any size highly unlikely for following reasons:
  - amount of fissile material must be sufficient to achieve supercritical mass for whatever compression mechanism to be employed

    - — timing between obtaining supercritical mass of fissile material and generation of neutrons to obtain chain rection must be precise
    - — simultaneous initiation of multiple detonators for implosion device essential for achieving supercritical mass
  - assuming nuclear device small enough to easily carry in suitcase could be created, such device could not be hidden remotely for many years until used – would require some maintenance to remain serviceable
  - nonetheless, suitcase nuke myth lives on

Slide 18 – reprocessing used nuclear fuel will lead to proliferation of nuclear weapons myth

  - anti-nuclear people falsely contend that reprocessing used nuclear fuel produces weapon-grade plutonium

Slide 19 – production of plutonium in LWR fuel

  - in LWRs U-238, comprising more than 95% of nuclear fuel, captures thermal neutrons to create Pu-239 having radiological half-life of 24,000 years
  - 26.5% of time capture of thermal neutron by Pu-239 produces Pu-240 having radiological half-life of about 6,600 years
  - Pu-240 captures thermal neutrons to produce Pu-241 having radiological half-life of 14.4 years
  - 27% of time capture of thermal neutron by Pu-241 produces Pu-242, which does <u>not</u> fission
  - Pu-240 and Pu-242 just neutron absorbers (also called neutron poisons since they remove neutrons that could otherwise initiate fission events)

Slide 20 – Pu buildup in light water reactor fuel

  - graphic shows buildup of plutonium isotopes in uranium-fueled nuclear reactor as function of fuel irradiation time (i.e., reactor operating time)
  - Pu-240 buildup in fuel exceeds weapon-grade limit of 7% in 1000 to 2000 hours (45 to 90 days) of reactor operation

Slide 21 – why Pu from nuclear fuel reprocessing not suitable for nuclear weapons

  - LWRs refueled after 12 to 18 months of operation, at which point Pu-240 makes up more than 18% of plutonium in nuclear fuel
  - in plutonium nuclear weapon neutrons from spontaneous fission of Pu-240 (small, but significant rate) causes premature fission of Pu-239 atoms
    - — Pu-240 content of plutonium weapon must be limited to less than 7% to prevent adversely affecting weapon yield
    - — to limit Pu-240 buildup below 7%, LWR fuel would have to be removed from reactor between 45 and 90 days of operation

Slide 22 – world nuclear fuel reprocessing capacity

- table shows that nuclear fuel reprocessing has been taking place (outside the U.S.) for a long time and has not resulted in the proliferation of nuclear weapon-grade material
- Other Nuclear Fuels entry
  - Magnox reactors were graphite-moderated, carbon dioxide-cooled reactors
  - PHWR is pressurized heavy water reactor
  - compared to “light water” moderator, graphite and heavy water moderators
    - create different average neutron energy spectra, resulting in different balance between neutron capture and fission
    - absorb fewer neutrons, allowing use of natural uranium fuel and higher U-238 to Pu-239 conversion ratio
    - tend to produce different amounts of plutonium and other minor actinide isotopes in nuclear fuel

Slide 27 – nuclear weapon vs. nuclear reactor

- graphic illustrates uncontrolled fission nature of nuclear weapon design vs. uncontrolled condition that nuclear reactor designed to prevent
- neutron population vs time plots shown with both linear (left) and logarithmic (right) neutron population scales
- neutron population in nuclear weapon detonation increases by 8 orders of magnitude in less than one microsecond, as shown in top figures
  - achieved by designing weapon to achieve supercritical configuration held together long enough to fission significant amount of fissile material before device becomes disassembled by energy generated from nuclear reaction
- if nuclear reactor were to go prompt critical, neutron population would increase by factor of 2.7 in 100 milliseconds as shown in bottom figures
  - energy generated from rapid increase in nuclear fissions initiates physical state changes and chemical reactions of reactor core materials that result in subcritical core configuration